UNITED STATES DEPARTMENT OF AGRICULTURE
Cotton and Fiber Branch, U.S. Food Distribution Administration

A COTTON FIBER AND SPINNING TEST DEVELOPMENTS OF INTEREST TO GINNERS

By Francis L. Gerdes, Senior Cotton Technologist

Address, Oklahoma Cotton Ginners' Association, Oklahoma City, Okla., April 5, 1943.

Cotton research conducted, sponsored, and encouraged by Federal, State, and private agencies during the past 15 years, is paying high dividends and making distinct contributions to the wartime cotton program. During this brief time, numerous practical developments of considerable value have been effected, and many practices have been modified or introduced as a result of this intensified work on the part of research workers. New concepts of cotton problems have been developed, and ideas about a number of aspects have been changed. Many of us can remember when it was generally thought in some quarters that rough ginning was caused to a great extent by fast saw speeds. Now we have data which prove beyond a shadow of a doubt that increased saw speed reduces rather than increases rough ginning, and that the density of the seed roll is virtually the only mechanical factor in ginning that influences ginning preparation.

In the early years of the development and advocacy of the cotton gin drying processes by the U. S. Cotton Ginning Laboratory, it was thought by some consumers of cotton that this practice was generally injurious to the spinning quality of cotton. Through research, we have been able sufficiently to refine and modify the process and its use to overcome this criticism; and now at least 3 million bales of cotton are annually conditioned by this process with consequent improvements in ginning preparation of the cotton. The drying process in the early years of its adoption was criticized further on the basis of its alleged adverse effect on storage qualities of seed ginned from seed cotton conditioned in driers. Systematic investigations revealed that the drying of green, damp, or wet cotton before ginning did not increase the rate of deterioration of the seed in storage but actually caused retardation of the formation of free fatty acid.

Through ginning investigations conducted over a period of years, it has been proved that where one gin gives a higher gin turnout than another, the spinning quality of the cotton is not necessarily impaired by the higher turnout. Of course, when the seed are "skinned," so to speak, additional mill waste and neppier yarns result. By maintaining loose seed rolls, employing high saw speeds--600 to 700 revolutions per minute--and modern design saws of full diameter and in good condition, we have found that we can obtain a more nearly perfect removal of usable fibers from the seed, and increase turnout without the inclusion of substaple fibers.

In other fields of work, where cotton fiber and spinning tests have been used as a tool in determining quality relationships, many more important findings have been brought forward. In the field of cotton breeding, it has been definitely established that the variety of cotton is the most important single factor affecting spinning quality, and that staple length is not as important as once believed by many of us concerned with cotton production and marketing problems. It has also been definitely determined that place of growth is not nearly so important as generally conceded in influencing spinning quality of cotton.

Fiber and Spinning Tests Defined

It can readily be seen that fiber and spinning tests are playing an important part in bringing to light a better understanding of the factors influencing quality of American cotton. Cotton ginners, as processors of the cotton and through their local position of influence with growers in selecting cotton varieties and in other production practices, occupy a unique place in our program of cotton quality improvement. Therefore, fiber and spinning test information now available in connection with the program should be of interest and value to ginners. An attempt will be made at this point to give you an outline of fiber properties and spinning quality elements 1/ with which manufacturers are concerned in consuming our cotton.

Fiber tests by methods now available generally provide a fairly good indication of the spinning quality of cotton. Spinning tests provide a conclusive over-all measure of the usefulness of a cotton as well as its value.

Fiber quality elements which have been found to be correlated with spinning value include length, uniformity of length, strength, fineness, and maturity. Manufacturing waste, yarn strength and appearance, as well as manufacturing performance, are the principal items which determine the spinning utility of cotton.

These various fiber and spinning quality elements are now being measured in the laboratories of the Cotton and Fiber Branch of the Food Distribution Administration in connection with cooperative breeding, production, ginning, packaging, and marketing studies, as well as with the Fiber Testing Service program. Spinning tests are made at the Clemson, S.C., and College Station, Texas, laboratories; and fiber tests are made in the Washington, D. C., and Stoneville, Miss., laboratories, as well as in the Clemson and College Station laboratories.

1/ United States Agricultural Marketing Service. Cotton Fiber Testing Service. 1941. (Mimeographed)

The principal fiber tests include fiber length and length uniformity determination by the use of the Hertel fibrograph, fiber strength by the use of the Pressley tester, fiber fineness by the weight per inch method, fiber immaturity by microscopic technique, and cellulose alinement by the X-ray method. Other more laborious tests include fiber length distribution by the fiber array or sorter method, fiber strength by the Chandler bundle method, and fiber fineness by the cross section method.

In making the fibrograph determinations, the specimen of cotton to be measured is prepared by placing from 300 to 400 milligrams of cotton, drawn from several different parts of the sample, on one of a pair of combs, and then mixing and straightening the fibers by combing them from one comb to the other. The two combs with their fringes of straightened fibers are then placed in a Hertel fibrograph. A beam of light, passing through a slit, is directed through the fringe, beginning with the densest part and gradually moving toward the outer edge composed of the ends of the longest fibers. The light which is allowed to pass through the fringe is picked up by a photoelectric cell, and the electric voltage thus generated is indicated by a galvanometer. By means of a recording pen, a continuous curve is drawn by the instrument on a record card, showing the change in the amount of light transmitted through the fringe of cotton fibers as the slit passes over different portions. Information regarding the fiber length distribution of the cotton is then obtained by analyzing the curve on the record card. In routine testing, two measures are obtained from the card: the mean fiber length, and the "upper half mean" length, the latter being the average length of all fibers longer than the mean. The upper half mean has been found to be closely correlated with the classer's designation of the staple length. By dividing the mean fiber length by the upper half mean and expressing the quotient in percentage, a practical measure of the length uniformity of the fibers in the sample is obtained.

The Pressley strength tests are made from small tufts of fibers which are prepared by manipulating and combing a representative specimen drawn from the hand-mixed sliver and conditioned for at least four hours before testing. From this tuft, small ribbons of fibers are drawn and combed, each ribbon being about 1/2-inch wide and containing roughly 1,000 fibers. A ribbon is placed in a small pair of clamps, and the ends of the fibers sheared so that the length of the fibers is equal to the thickness of the clamps, or slightly less than 1/2 inch. The clamps are placed in the tester, and a load applied by allowing a weight to roll down a balance arm on the tester. When the fibers have been broken, the strength is read directly from the balance arm. The clamps are then removed and opened, and the broken ribbon is weighed on a torsion balance. The quotient obtained by dividing the breaking load by the weight of the ribbon is taken as the strength index. By the use of a conversion formula, developed in our laboratories, these indexes are converted to breaking strength in terms of pounds per square inch.

In making fiber fineness and immaturity tests, a fiber length array is first prepared. For the fineness test, 100 fibers are then drawn from each length group, and weighed. The average weight per inch of fiber in the cotton, in terms of micrograms (1/1,000 of milligrams) is obtained by weighting the data for the different length groups in proportion to their relative weights in the array.

Immaturity tests involve the preparation of a microscopic slide for each length group in a fiber array by placing somewhat more than 100 fibers on a slide with a cover glass, and "mercerizing" or swelling them by adding a few drops of 18 percent caustic soda solution. The slide is examined with a microscope, and the number of thin-walled or immature fibers determined by inspection and counting. A swollen fiber is considered to be thin-walled or immature if its wall thickness is less than one-half the width of the lumen or cavity within the fiber. The weighted average immaturity count is obtained from the counts of the different length groups in an array.

The X-ray determination of cellulose alinement involves the placement of a thread-wrapped bundle of fiber of known diameter under tension in a camera attached to the X-ray machine, and the recording of the X-ray diffraction pattern on a photographic film. With the use of a microphotometer of special design, an angular measure is obtained of a portion of the arc diffracted from the 002 spacing in the crystal. This angle is an index of the average angle between the long axis of the cellulose molecules in the crystal and that of the fiber. The angle of the cellulose molecules has been found to be correlated with the strength of the undamaged fiber, and gives an indication of the strength of the cotton.

The spinning tests made in the Cotton Testing Laboratories are conducted by trained technologists who use techniques developed and standardized in our laboratories over a period of years. The manufacturing equipment used is essentially of commercial design, although a few minor modifications have been made to adapt some of the machines to the special requirements of spinning tests of small samples.

It is common commercial practice to produce "carded yarns" from most cottons shorter than 1-1/8 inches in staple length, and "combed yarns" from most cottons longer than 1-1/8 inches in staple length. In lengths of about 1-1/8 inches, some cottons are spun into carded and others into combed yarns, depending upon the kind of product being made. The difference between the two qualities of yarn lies in the fact that in the production of combed yarn, the cotton is passed through a combing machine, in addition to the card. The comber takes out from 9 to 25 percent additional waste in the form of "noils," consisting chiefly of short fiber, and neps and particles of foreign matter that have passed through the card. Combed yarns are smoother, cleaner, and stronger than carded yarns. Practically all commercial yarn finer than 45s to 50s count is combed.

During the spinning tests, the percentage of each important type of waste removed during manufacturing is determined. These include (1) picker waste, and (2) flat strips, cylinder and doffer strips, and other waste (motes and fly waste) removed by the card.

The yarns obtained from the manufacturing laboratory are tested for skein strength and size in the yarn-testing laboratory, the recognized standard procedure for such tests being followed. The individual strength and size value for 25 to 60 skeins of yarn are averaged for each count spun. The skein strength of a yarn is the most important single index of quality obtained from a spinning test. It is an indication of the spinning and weaving quality of a cotton, and of its utility or suitability for various kinds of products.

The test yarns are also graded for appearance, giving an index of their suitability for threads and fabrics such as sewing thread, dress goods, and the like, in which appearance is an important quality element. This is done by winding the yarns on black boards and comparing them with standards developed by the Department. Yarn may range from "A+" to "D-" in appearance.

The fourth item of quality provided by the spinning test is the over-all manufacturing performance which is observed by the technologist during the tests. It is important to a cotton manufacturer to know whether a cotton has any peculiarities that might have an effect on the efficiency of a mill when spun on a commercial scale. For example, a cotton might require an unusually low amount of roving and yarn twist, a characteristic that would reduce manufacturing costs to some extent. Or, another cotton might reveal during the test a tendency toward roller lapping for one of several reasons, foretelling serious trouble and increased manufacturing costs for a mill purchasing such cotton.

When long staple cottons are submitted for tests, combed as well as carded yarns are spun and tested in the laboratories. The chief advantage of employing both types of test for long staple cottons is that it not only permits a comparison of a cotton with findings from large numbers of carded cotton, but it also provides concrete evidence of the kind of yarn the cotton will produce when manufactured in the usual manner for such a staple length. It shows the actual strength and appearance of combed yarn spun from the sample, and also demonstrates whether the improvement in yarn strength made by the combing process is normal or above or below normal in this respect.

Ginning Information Proved in Fiber and Spinning Tests

As previously stated, the cotton quality phases of the ginning investigations being conducted by the Department embrace fiber and spinning tests as well as classification. Quality influences of different methods of ginning are in terms of information derived through these tests; therefore the findings are more comprehensive and significant than would otherwise be the case. At this point, it may be of interest to elaborate on some of the results of these studies.

Cotton storage test results: Tests involving the storage of seed cotton for different periods under various conditions prior to ginning have failed to reveal any increases in fiber length or fiber strength as a result of storage and conditioning before ginning. The grade improvements of the lint associated with drying green, damp, or wet cotton in storage for only 1 week generally was consistent and as high as those representing cottons subjected to longer periods of storage. In the case of wet seed cotton, free fatty acid development in the cottonseed began to take place after 3 to 4 weeks' storage as a result of heat generated by the excess moisture in the seed cotton.

Sun-drying test results: Concurrently with artificial drying tests on green, damp, or wet seed cottons, portions of the cotton have been exposed on tarpaulins to dry in the sunlight to similate an old-time practice which is now seldom used. The tests have shown that drying in this manner resulted in excellent preparation or smoothness of the ginned lint but was harmful to its spinning utility. Large increases in manufacturing waste and important decreases in yarn strength resulted. Artificial drying at the gins by approved methods was found to be much safer than sun drying.

Artificial drying tests: In the tests of mechanical cotton driers, smoother ginning and higher grades resulted from the reductions made in moisture content by these units. Fiber length, on the average, was preserved when the cotton was dried at 150° F., but higher drying temperatures sometimes resulted in ginned lint with slightly shorter length. In many cases, drying temperatures above 200° F. were associated with shortening the staple by 1/32 to 1/16 of an inch. Spinning tests made over a period of years on undried and dried cottons have shown that temperatures above 200° F. definitely resulted in weaker yarns; but when the recommended temperature of not more than 160° F. was used in drying, that the grade of the cotton was definitely improved without a significant loss in strength of the yarn. In tests with 8 different cottons, aliquot portions of each of which respectively were ginned in a green and damp condition and, after having been dried at various temperatures up to and including 190° F., the dried cotton produced yarns that were only 1 percent weaker than those spun from the undried cotton. Such a decrease would be negligible from any practical standpoint in the processing of cotton. The benefits from drying were reflected in lower waste removed by the picker and carding machinery; and the difference in waste removal was about as much as the average difference between Middling and Strict Middling cotton.

Seed roll density test results: Tests have been made to determine the relative influence on lint quality of loose seed rolls resulting from normal feeding of cotton to gin stands and of dense seed rolls produced by heavy feeding and dense seed rolls associated with seed boards set to produce close ginning. As compared with loose seed-roll ginning, the close ginning method reduced the quality of the lint more than the heavy feeding method. The increased damage to lint quality produced by close ginning over that produced by heavy feeding was

reflected in increased manufacturing waste and in a greater reduction in yarn strength. As compared with loose seed-roll ginning, tight seed-roll close ginning increased manufacturing waste 1 percent, and tight seed rolls resulting from heavy feeding, 0.5 percent. Also, the tight seed-roll close ginning method significantly reduced yarn strength and appearance, whereas no real effects on these quality elements were noted with tight seed rolls resulting from fast feeding of the cotton to the gin stands.

Cotton Variety Improvement Information Enhanced by Fiber and Spinning Tests

For a long time State Agricultural Experiment Stations have been conducting variety tests for the purpose of determining the most profitable varieties of cotton to recommend to producers for planting. Through the cooperation of the Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, and the Cotton and Fiber Branch, Food Distribution Administration, promising varieties of cotton are now being subjected to fiber and spinning tests in an effort to supplement the yield, staple length, money value, and other field data with quality test results useful in indicating the spinning utility of the different cottons.

State Agricultural Experiment Stations are now in the position to recommend varieties that combine relatively high production performance with satisfactory spinning quality. Moreover, the tests have brought out very definitely that the variety of cotton is the most important single factor affecting yarn strength. Place of growth is not generally so important, but season sometimes affects yarn strength to a great extent. Under adverse conditions, a given group of varieties will show the same relative yarn strength differences as when grown under ideal conditions for good spinning performance. These relationships have been clearly brought out in Figure 1 of the Texas Agricultural Experiment Station Bulletin No. 624. In this same publication, information is presented to the effect that staple length alone is not a reliable indication of yarn strength of a given variety of cotton. Although a cotton grown at several places shows a wide range of staple lengths, the yarn strengths do not necessarily vary in proportion to the staple lengths. Other fiber properties play an important part in these relationships, such as fiber strength, uniformity, fineness, immaturity, etc. Cotton breeders, therefore, are now taking these elements of quality into consideration in their breeding and improvement work.

Testing Service for Cotton Breeders Provided by Fiber and Spinning Tests

Under a recent act of Congress, the Food Distribution Administration is making fiber and spinning tests for cotton breeders and others on a fee per sample basis to provide long needed information basic to improvement in the spinning value of cotton varieties 2/. This service has been available to breeders for 2 years. The first year, breeders submitted a total of about

---

2/ Promulgation of Regulations of the Secretary of Agriculture Governing Cotton Fiber and Spinning Tests under the Act of April 7, 1941 (Promulgated November 2, 1941 and Amended November 2, 1942) (Mimeographed)

1,300 samples for fiber tests and 55 samples for spinning tests; and during the current year, they have already obtained fiber test information on more than 2,000 samples and spinning test results on more than 100 samples. The fiber test samples represent progenies and new strains, as well as established varieties.

With the aid of fiber test information, the breeders can ascertain the most promising progenies for field testing as new strains, and for determining the best all-round new strains for further field observations or for planting on larger acreages for increasing seed production. After new selections have been subjected to these field tests, with the aid of fiber test data, the more outstanding new strains are submitted to our laboratories for spinning tests to provide results upon the basis of which the breeders determine strains for propagation.

Already several breeders have introduced new and superior cotton varieties for commercial planting after putting them through these stages of testing. Some of the new varieties have improved spinning quality combined with better field performance. Others have been improved in yield without sacrificing spinning quality. Some new varieties possess high spinning value but have the same yield as varieties which they replaced. Most of the breeders' efforts are being directed toward developing varieties of cotton that would have a staple length ranging from 15/16 inch to 1-1/8 inches, depending on the season and place of growth. Especial effort is being made through selection and hybridization to produce varieties of cotton having a staple length of 1-1/16 inches but possessing other improved fiber qualities which will make their spinning quality comparable with that of existing long staple varieties, 1-1/8 inches or longer in staple length.

Since it is now possible to make fiber tests on very small, 1- to 2-ounce samples, and spinning tests on 5-pound samples, the breeders through the cotton testing service can greatly speed up their work and not be forced to wait long periods for new varieties to prove themselves in mill tests requiring large quantities of cotton. That is, shifts to new and more promising strains can more readily be made. Much extra time and effort on the part of the breeder can be saved by following the new procedure in developing improved strains of cotton. Our producers will be supplied with good seed much faster now than in former years.

It seems appropriate to conclude this paper on the subject of fiber and spinning tests by encouraging ginners to continue to become better acquainted with cotton problems and research activities, and to disseminate the information so obtained to producers who, through the ginners' help, can quickly change the quality of the cotton being produced in this country. Efforts are being made through the testing program to aid the manufacturers in determining fiber qualities that more nearly meet their spinning requirements, and a closer working relation between manufacturers and producers should bring about the production of cotton crops having a range of qualities that will more adequately supply the current needs of manufacturers. The 1942-43 supply of 13/16 inch and

shorter cotton equaled requirements for approximately 5 years; of 7/8 inch and 29/32 inch for 3-1/2 years; and of 15/16 inch and longer for a little over 1-1/2 years. Obviously, as a war measure, producers will give these figures serious consideration between now and planting time, and will contact the State Agricultural Experiment Stations for information on spinning quality as well as production performance of cotton varieties.

In 1943, emphasis should be placed on the need for the production of higher grade cotton. The 1942-43 supply of Strict Middling and better cotton equaled requirements for only about 1-1/4 years, or about enough to last until the 1943 crop begins to move. Supplies of Middling were equal to requirements for about 1-1/2 years, of Strict Low Middling for a little over 2 years, of Low Middling and lower for 4 years. With the burdensome carry-over of low grade and short staple cotton in sight, and the growing needs for higher grade and longer staple cotton, our cotton program for 1943 calls for the production of more longer staple varieties, especially in areas where this will not materially reduce yields of high-grade cotton. Higher grades as a result of better picking and ginning will also be one of the principal goals in the program.